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*Research Article*

# Combat Response Training Tester Based on Intelligent Force-Measuring Sensor and Digital Circuit

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In combat sports, the team members take attack and defense as the core of sports, and the technical movements are not periodic and the application process is irregular. During the competition, observe the opponent's neutral position, judge timely, and react quickly. At the same time, athletes are required not only to master skilled technical movements but also to have rapid and accurate adaptability. In order to improve athletes' rapid response ability, according to the rapid response training scheme, a combat response training tester based on a force-measuring intelligent sensor and digital circuit is designed to improve the athletes' response ability. Firstly, a comprehensive test system of combat trainer is designed based on the intelligent force-measuring sensor and MSP430, which can measure the response time, speed, and strength of boxing. Secondly, a wavelet filtering algorithm is used to filter the sensor measurement data. Finally, the striking force and striking time of each action are recorded by sensors and data acquisition devices to reflect the striking effect and reflect the "accurate" objectives of the project characteristics. Based on the noninterference and anti-interference of e-touch piezoelectric film, it can be made into universal force-measuring sensors of different specifications for fight competitions according to needs. After being connected into a module network in parallel, it can be connected with the microcontroller to determine the hit area. In addition, the team reaction training test device has laid a foundation for the scientific evaluation of improving the team members' reaction ability and attack defense conversion ability. The launch of the comprehensive ability tester for combat athletes introduces the previous fuzzy evaluation of athletes' comprehensive ability into a new way of scientific quantitative measurement and evaluation, which will provide a scientific basis for the selection of combat vibration items, the regulation of training process, the inspection of training effect, and the formulation of enrollment and examination standards for sports colleges and universities. The results show that the instrument can obtain the parameters of hitting strength, strength endurance, hitting speed, speed endurance, hitting impulse, and hitting power of sports biomechanics on the group of fighting events, which provides a reliable basis for coaches to implement teaching and training for athletes.

## 1. Introduction

Since the reform and opening up, people's living standards have been continuously improved [1]. After solving the problem of food and clothing, health has become a major concern of the society [2]. With the successful holding of the 2008 Beijing Olympic Games, China has officially entered the ranks of sports powers and realized the dream of becoming a sports power. Nowadays, national fitness has become a topic of increasing concern. In fact, after elite sports, there must be a vigorous national fitness movement [3]. Due to the accelerated pace of modern people's life, the shortage of urban land, and the large population of our country, the places for citizens' sports and fitness in cities are becoming more and more limited [4]. Therefore, gyms have become more and more people's fitness choices. In addition, the changes in people's living conditions today also give fitness equipment a space for considerable development. In the past, most people were engaged in physical labor, so they did not have much interest in fitness after work; more and more people engaged in mental work [5]. Because they spend a long time in the office, they take the bus even when they go to and from work. Therefore, these people lack necessary exercise, and their bodies are generally in a subhealth state. Many people catch a cold when they encounter the wind. For these people, sports and fitness have become extremely important. After all, the body is the capital of the revolution. Due to the limitations of space and time, many mental workers choose to go to the gym for fitness [6].

Wushu is the quintessence of the Chinese nation. Chinese people have always had a yearning and love for boxing Wushu [7]. It can be said that almost every Chinese has a Kung Fu dream when they are young. Therefore, the fight training device in the gym is bound to be welcomed by many people [8]. This device integrating testing and fitness can not only help those who like boxing to do fight training but also let people release the pressure in work and life in the process of boxing [9]. Modern fight training equipment is no longer a wooden stake in ancient times [10]. It is a comprehensive training system integrating fitness and testing. The target surface of the fight training device is no longer a hard material like a wooden pile, but is connected to a cylinder [11]. When boxing, the air is squeezed and the target will move back. In this way, a buffer of a certain distance is formed to protect the fist. The change of air pressure in the cylinder can also just reflect the fist force [12]. The signal of the change of air pressure is collected by the air pressure sensor and then sent to the a/d converter of the single-chip microcomputer to obtain the fist force [13]. The speed measurement principle of the system is to use the hc-sr04 ultrasonic sensor installed above the target surface to continuously emit ultrasonic waves at equal time intervals, detect the distance of the fist in the process of punching through the reflected wave, and obtain a speed through the ratio of the distance difference measured every two adjacent times to the time used. In this way, multiple speed values can be obtained in the process of punching, and the maximum value can be calculated in the program and defined as the fist speed. The reaction time of human boxing is completed by the timer of MSP430 single-chip microcomputer. Therefore, the combat trainer can be used as a continuous boxing exercise and can also be used to test the reaction time, boxing speed, and boxing strength of a boxing [14]. Literature [15] takes judo competition as the object and puts forward a time-motion performance evaluation method. In the following years, the literature [16] used the time-dynamic performance evaluation method in the research of comprehensive fighting movement, which was quite effective and was followed by other scholars. Literature [17] published papers to look for ways to distinguish the physiological characteristics of high-level and low-level comprehensive wrestlers and the physiological differences between ground skills and standing skills. He found that the level of comprehensive wrestlers largely depends on the anaerobic ability of the athletes [18]. The requirements for anaerobic ability of ground skills are higher, and the ratio of motion to stop is significantly higher than that of standing skills. Standing skills require higher dynamic strength and explosive power. Literature [19] proposed that the movement stop ratio of comprehensive fighting was 1 : 2 to 1 : 4, which was between the typical ratios of judo, wrestling, karate, and Taekwondo, regardless of a round interval, reflecting the combination of ground technology and standing technology; most competitions end in the third round, and the high-intensity movements mainly belong to the ground entanglement part [20].

The rest of this paper is organized as follows. Section 2 discusses the overall design of the combat response tester, including the system structure design for the combat response training tester and the hardware circuit design of the system. In Section 3, research on a pressure-testing algorithm based on wavelet filtering algorithm is studied. Section 4 presents the test results. Finally, the full text is summarized in Section 5.

## 2. The Overall Design of Combat Response Tester

*2.1. System Structure Design for Combat Response Training Tester.* The reaction training tester is mainly composed of a hitting model, hardware, control and data acquisition, and human-computer interaction. The striking model is the basis of the whole equipment, and the characteristics of "fast, accurate, and very" of fighting sports are fully considered. The model is mainly composed of a strike module, base post, and indicator light. The installation position of the indicator light is convenient for athletes to observe. The indicator lights of different colors at different positions are on, which requires athletes to respond quickly according to the training plan arranged by the coaches and complete the corresponding technical and tactical actions to improve the reaction ability of the team members. The striking target in the striking module is the target for professional training. The striking position is marked, and the sensor is located directly below the striking position. The striking force and striking time of each action are recorded by sensors and data acquisition devices to reflect the striking effect and reflect the "very" and "accurate" objectives of the project characteristics. A sliding groove is designed in the base column to facilitate the adjustment of the height of the striking module, so as to adapt to athletes of different heights. The chassis can not only simulate the swing range of the sandbag but also prevent the injury of team members by adjusting the tightness of the 8 springs. The overall structure of the combat response test instrument system is shown in Figure 1. The design of the system includes an upper computer terminal and a lower computer. The lower computer is connected to MCU through WiFi. The system adopts the modular design concept, which divides the system into a microprocessor, signal acquisition module, WiFi communication module, and system power module. This design is based on an MSP430F149 single-chip microcomputer produced by TI Company of the United States as the application foundation and effectively combines with various hardware systems to complete the overall design of the system. MSP430F149 is the core control module of the system and the central processing module. It realizes the main interaction of man-machine information through the combination of independent keys and a 12864LCD liquid crystal display. The user can operate according to the current operation level displayed on the screen by pressing the key. After the user selects a gear as the flexibility training intensity, the controller will select the corresponding gear channel through a certain logic operation; then, the user selects the ascending or

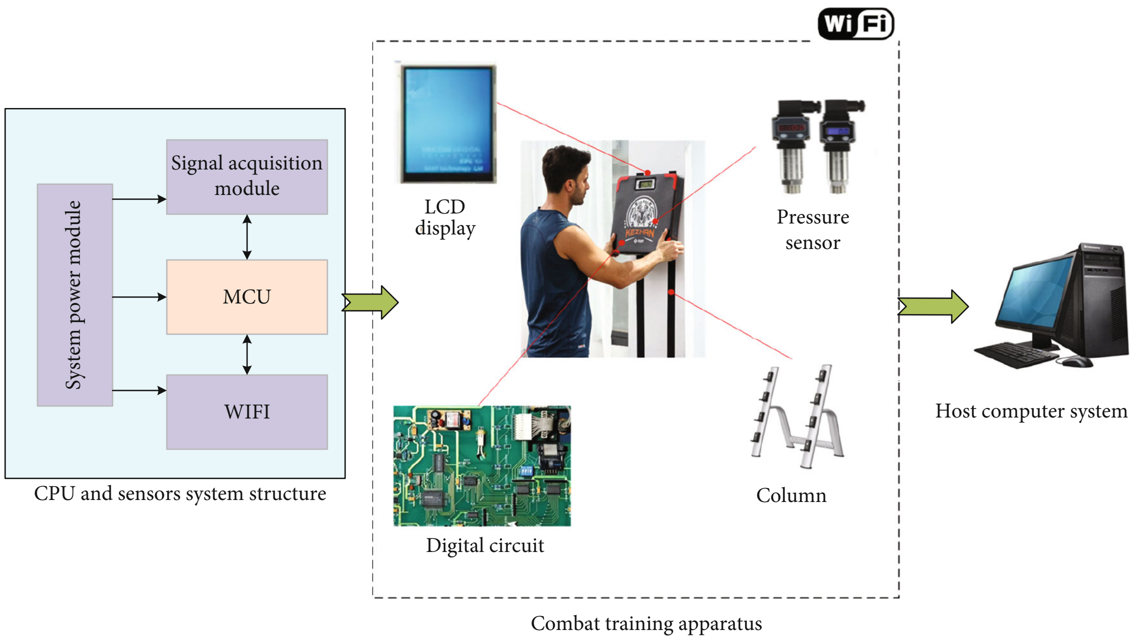


FIGURE 1: The structure of the multiple physiological parameter measurement systems.

descending according to the screen prompt, and the controller controls the forward or reverse rotation of the motor through certain logic operation to realize the ascending or descending of the trainer. At the same time, the user's selection will be displayed on the LCD screen.

*2.2. Hardware Circuit Design of the System.* The hardware circuit diagram of the fight training instrument is shown in Figure 2. The instrument is composed of a single-chip microcomputer with a display screen and a function control keyboard on the periphery and a target mold (a reaction mold and a gravity sensor mold that randomly displays the strike points). There are decoding, coding and sensor signal acquisition, and holding circuits in the target mold. When working, the indicating signals of each hitting point are generated by the single-chip microcomputer program. When the athlete hits the target mold, the mold circuit will return the athlete's action signal to the single-chip microcomputer, which will display the test results on the display screen or transmit the data to the advanced computer.

The tester has five operating modes. When in use, the user can select the working mode and set the test parameters through the keyboard on the host control panel and select the target mold at the same time. (1) Reaction ability test: the main machine is equipped with a standard mold with random luminous dots. Set the random times: the light on prompt time, record the time gap between the light on and the target hit, and display the cumulative result of the effective response time. (2) Hit rate test: set the number of random lights on $N$, record the athlete's effective hitting times $m$, and then, the ratio of $m$ to $n$ is the hit rate. (3) Striking force test: the main machine is equipped with a gravity-sensing mold. Set the function key "force" to measure the striking force of the athlete. This status is a dynamic test. (4) Weighing: set the function key "weigh," at this time, the tester is a 500 kg scale, which can be used to divide the weight level of athletes. This status is a static test. (5) Hitting frequency test: set the function key "n/min" to evaluate the effective hitting times of athletes in unit time (meaning that the strength must be greater than a given value). Features of the tester: it can be used by a single machine, small and flexible, and can also be connected to the computer for statistical management; the interface between the target mold and the host adopts the plug-in connection mode, which can be flexibly replaced according to the test object and test item; the software is portable and easy to upgrade the erasability of a single-chip computer program. Parameter indicators can be set according to user requirements.

Furthermore, the core processor of the system is MSP430F149, which needs to provide a +5 V power supply. The OP07 used in the system design differential amplifier circuit needs to provide ±5 V power supply. Therefore, a 220 V general AC power supply cannot meet the design requirements. It must be processed by the peripheral power circuit to obtain the required voltage to supply power to the system. The spoke pressure sensor is adopted, which has high sensitivity, good linearity, stable performance, a large pressure range of 0-1000 kg, an output voltage of 0-10 V, and a response frequency of 1000 Hz; the data acquisition system uses the shelf product USB-2852a of Beijing Altai Technology. The acquisition card is a data acquisition card based on a USB bus, which can be directly connected to the USB interface of the computer to form a data acquisition, waveform analysis, and processing system in various fields such as laboratories and product quality inspection centers.

## 3. Research on Pressure-Testing Algorithm Based on Wavelet Filtering Algorithm

*3.1. Design of Force Sensor Based on e-Touch.* The e-touch piezoelectric film contains many flat hole structures, in

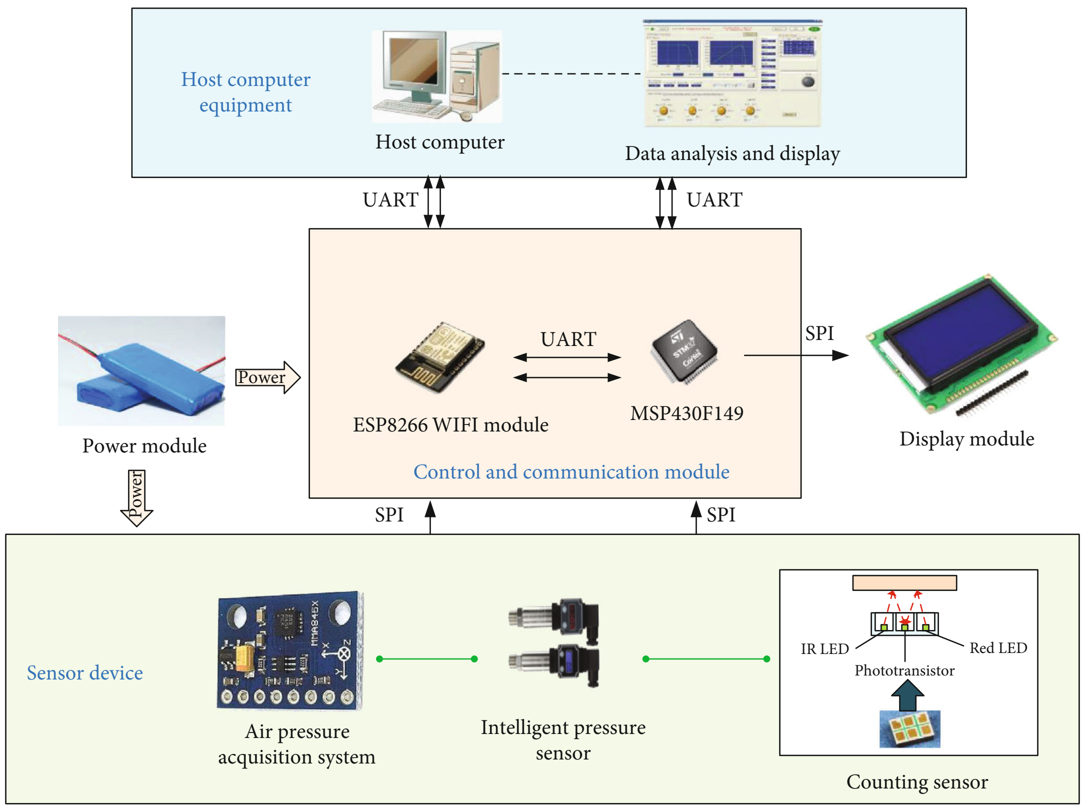


Figure 2: The hardware structure of the health bracelet terminal.

which permanent positive and negative charges are stored. When the piezoelectric film is subjected to dynamic stress, the thickness changes and corresponding charges are generated. These charges accumulate on the upper and lower electrodes of the film, resulting in charges corresponding to the force. The e-touch piezoelectric film produced by Beixin Electronic Technology was selected in the test. Its main parameters are piezoelectric charge coefficient 10 pc/n, piezoelectric frequency range 1 khz~100 khz, capacitance 17 pf/cm$^2$, impedance 10 m$\Omega$/cm$^2$, and pressure range 0.1 kPa~1000 kPa.

After learning from many mature advantages of Taekwondo electronic protector and studying its induction recognition stability, signal acquisition, collision misjudgment, and so on, in this paper, a kind of force-measuring sensor for an electronic protective device is made and realized by sticking buffer material on the front and back sides of the ordinary e-touch piezoelectric film. The overall structure of the sensor system is designed in Figure 3. It is embedded in the protective device for use and choose piezoelectric films of different shapes according to the shape and thickness of the protective device, adjust the material and thickness of buffer materials on both sides to meet the needs of different gender and level competitions, and eliminate their own and external disturbances. Flexible shielding materials and shielding wires are used to shield power frequency and electromagnetic interference, and finally, the sensor is embedded in the protective device.

A group of force-measuring sensor modules with the same shape, thickness, and impact resistance value is connected in parallel through the bus and embedded in the used protective gear or corresponding equipment, and the distribution position is adjusted to ensure that at least one sensor module can be effectively hit during use. The positive output end of each sensor module is connected to the bus after connecting the diode to avoid mutual influence.

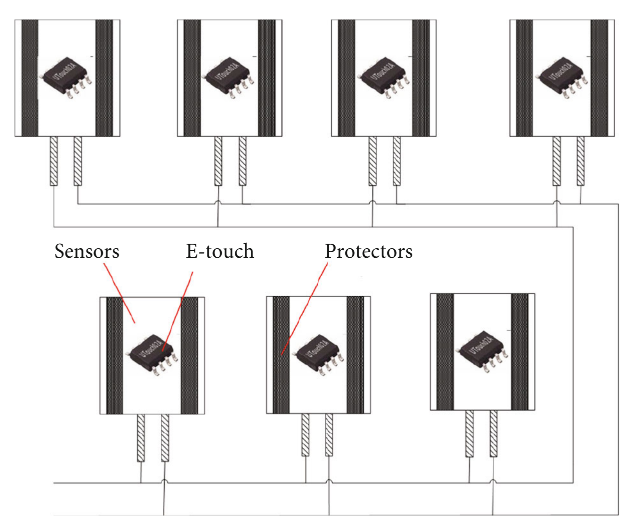


Figure 3: Structure diagram of pressure sensor based on e-touch.

*3.2. Wavelet Filtering Processing of Pressure Measurement Data.* The function (or mathematical principle) of continuous

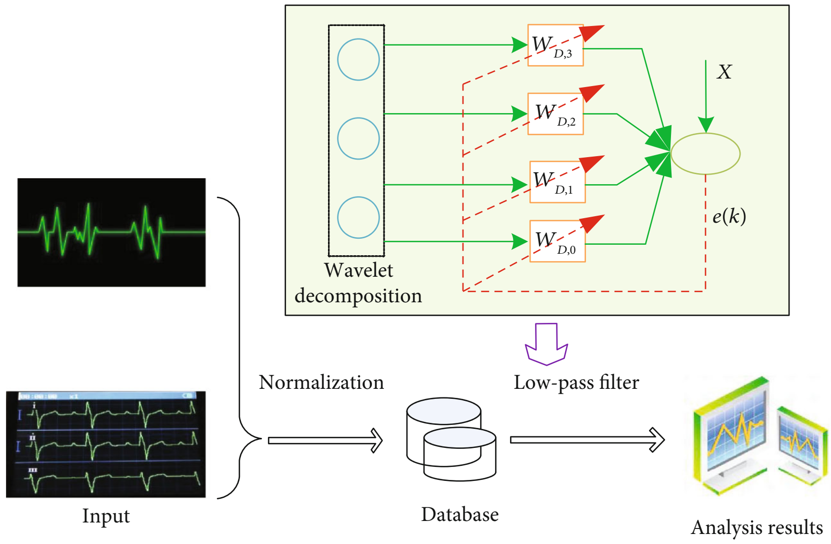


FIGURE 4: Structure diagram of pressure sensor based on e-touch.

wavelet filter is the same as that of a digital filter. The difference between the two is that the former is a continuous function and the latter is a finite discrete sequence. This difference directly leads to the difference in the implementation of filtering between the two. That is, after a basic continuous function filter is given, people can arbitrarily adjust its filtering scale and adapt to the data with any sampling rate, even to the data with unequal interval sampling. As for digital filtering, when the scale or sampling rate changes, people often need to reconstruct the corresponding digital filter. At the same time, the filters applied to pressure instrument data and aerodynamic data are different (low-pass and derivative, respectively), but the two types of filters must be strictly consistent in terms of filtering scale. In this regard, compared with digital filters, the continuous function filter is easy to realize the scale matching in the filtering process because it is easy to adjust the scale. This paper attempts to use the low-pass parent wavelet and the first-order derivative and second-order derivative mother wavelet to replace the digital filter to filter the pressure measurement data.

The implementation block diagram of the wavelet filtering algorithm is shown in Figure 4.

As shown in Figure 4, the low-pass filter is the core of the whole algorithm. Next, the wavelet filtering algorithm will be used to process the sensor data. Given the function $f(t)$, define the following transformation [21]:

$$\begin{aligned} W_0^\tau f(t) &= f * \theta^\tau(t), \\ W_2^\tau f(t) &= \frac{1}{\tau^2} f * \psi^\tau(t). \end{aligned} \tag{1}$$

Traditionally, $\theta^\tau(t)$ is called the smooth function (or sampling function). In wavelet theory, $\psi^\tau(t)$ is called parent wavelet (or scaling function). People can construct innumerable parent wavelets that satisfy Equation (3), such as the Shannon function, Hnr function, and B.spline function. $\tau$ is the time scale where $^*$ represents the convolution operator, which is easy to obtain

$$W_2^\tau f(t) = \frac{1}{\tau^2} f * \left(\tau^2 \frac{d^2\theta^\tau}{dt^2}\right)(t) = \frac{d^2}{dt^2}(f * \theta^\tau)(t) = \frac{d^2}{dt^2} W_0^\tau f(t). \tag{2}$$

$W_0^\tau f(t)$ is the result of low-pass filtering of $f(t)$ on a time scale $\tau$. Formula (2) shows that $W_2^\tau f(t)$ is actually the second derivative of $W_0^\tau f(t)$, that is, the second derivative of the low-pass filtering result of $f(t)$ on $\tau$, so $\psi^\tau(t)$ can be considered as the second derivative filter on $\tau$. As long as the speed of punching remains stable, the time scale and space scale of pressure measurement are equivalent.

Therefore,

$$\Delta g^\tau(t) = W_0^\nu \Delta g(t) = \Delta g * \theta^\nu(t), \tag{3}$$

where $v$ is the speed of punching. Construct parent wavelet and parent wavelet as

$$\begin{aligned} \theta(t) &= G(t)S(t) = e^{-\left(t^2/2\delta^2\right)} \cdot \frac{\sin \pi t}{\pi t}, \\ \psi(t) &= \ddot{\theta}(t) = e^{-\left(t^2/2\delta^2\right)} \left(\frac{t \sin \pi t}{\pi \delta^4} + \frac{(\sin \pi t/\pi t) - 2\cos \pi t}{\delta^2} + \frac{2(\sin \pi t/\pi t) - \pi t \sin \pi t - 2\cos \pi t}{t^2}\right), \end{aligned} \tag{4}$$

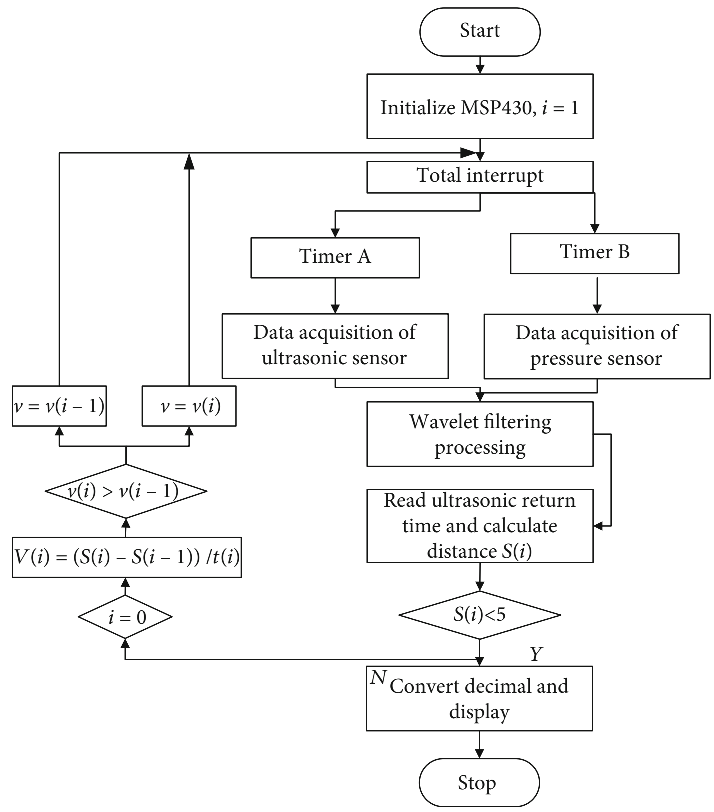


FIGURE 5: The algorithm flowchart of prediction sampling frequency.

$G(t)$ and $S(t)$ are Gauss function and Shannon function, respectively, and $\delta$ is the constant that controls the length of the filter window. $S(t)$ is the best low-pass filter in theory, since its frequency response is the most ideal Harr function. If the filtering scale (cut-off half wavelength) of $\theta(t)$ and $\psi(t)$ is dimensionless 1, the parent wavelet $\theta^{\tau}(t)$ and parent wavelet $\psi^{\tau}(t)$ after time scale calibration can be obtained by Equation (1).

However, $S(t)$ decay rate $O(1/t)$ is too slow to be directly used for filtering. In Equation (4), $G(t)$ is introduced so that $\theta(t)$ has a faster decay rate, which is nearly a compactly supported (finite length). When $\delta$ is large enough, $\theta(t)$ decibel defined by Equation (3) is close to the low-pass requirements in Equation (3). And $\theta(t)$ frequency response is very close to the Harr function; $\theta(t)$ constructed from Equation (4) is very close to the bandpass requirements. $\theta(t)$ and $\psi(t)$ can be regarded as parent wavelets and parent wavelets, respectively, and their basic filtering scales (cut-off half wavelength) are both 1 (dimensionless). When the scales of both are calibrated and adjusted, the same filtering scales can be ensured as long as the scale parameters $s$ of both are kept equal. On the basis of multiresolution analysis of signals, Mallet and Meyer proposed a fast algorithm for computing discrete orthogonal wavelet transform, namely, Mallet algorithm. By orthogonally projecting the signal $x(t)$ into the spaces $Vj$ and $Wj$, the discrete approximation signal $cj(t)$ and discrete detail signal $dj(t)$ of $x(t)$ under resolution $j$ can be obtained. The whole flowchart is designed as shown in Figure 5.

As is shown in Figure 5, the fight trainer system measures the reaction time of the boxer by timer $B$. First, set the counting mode of timer $B$ to continuous counting. Since the system clock is set to 8 MHz and the count value CCR0 is 8000, it takes 1 ms to count each time, and the millisecond count value is saved in register m_second, when the value of second m_second reaches 1000, the second register carries one bit, and m_second is cleared. Since the maximum reaction time is set to be no more than 10 ms, it is unnecessary to consider the carry problem of seconds and minutes. The cut-off condition for timer B timing is the fist target spacing $s > 5$ cm, so when this condition is met, the m_second is merged and stored in time $t$. The timer interrupt is used in the program design. When the count value reaches 8000, it enters the interrupt function, performs time conversion, sets the count value, and then returns to the main function cycle for the next count until the cut-off condition is met. Furthermore, the ultrasonic speed measurement program is mainly completed by timer $A$; that is, timer $a$ records the echo high-level time. Setting P1.2 to CCIOA, timer A captures input. When the high level at the capture input comes, it starts counting, that is, the rising edge capture; when the capture input low level arrives, the counting ends, that is, the falling edge capture. Take the timer count value as the timing time. The distance of the fist is calculated from the timing time and the ultrasonic speed. After the program delays for 4 ms, the next measurement is carried out. The speed can be calculated from the time difference and distance difference of continuous measurement. The purpose of dynamic speed measurement can be achieved by continuous measurement in the cycle program until the speed measurement cut-off condition $s > 5$ cm is met.

## 4. Analysis of Test Results

The test process of the beat tester is as follows: connect CH1 and CH2 channels of the oscilloscope to the output end of the force-measuring sensor module and the output end of the conditioning circuit, respectively. Apply different levels of dynamic impact force to the sensor module through the dynamic impact force calibrator and observe the corresponding output peak value by the oscilloscope. The experimental results are shown in Table 1.

When the sensor module of the same specification is replaced for measurement, its output voltage changes slightly with the output voltage of the conditioning circuit, but the output is proportional, within a difference of ±0.3. In the test, when the output voltage of the sensor module is 115 V, it does not change, obviously reaching the upper limit of the generated charge. In order to meet the use requirements, replace the buffer material with a higher damping coefficient and calibrate again. The calibration results of a group of sensor modules with the same specification can also be noted. The output results before the output voltage no longer changes have a certain deviation, but they all change with the change of the force application height and the proportion is basically the same, ranging from 0 to 0.5.

Watchdog timer (WDT) is a common component in the design of MCU. In practical application, due to the existence of interference noise such as power supply and other electromagnetic interference, it is easy to cause the MSP430 program to run away. At this time, it is necessary to effectively handle the program to make it run normally so that the machine can return to the normal working state. A watchdog timer is designed to solve this problem, and its function is particularly important in the loop program. In general, WDT is used by setting a timing time, which is just a little longer than the total time for program execution. When the timing time is up, the device will reset automatically. In the process of program execution, the watchdog timer will be reset automatically to start counting again; that is, the watchdog timer will not work under the normal operation of the program. However, when the program runs away due to interference, it cannot clear the WDT before the scheduled time is reached. At this time, the WDT will overflow, causing the system to reset, and the program will restart to run normally.

*4.1. Prediction Results of Sampling Frequency Based on BP Neural Network.* In order to accurately measure the impact force, each force-measuring sensor is calibrated by a dynamic impact force calibrator. Pull up the impact rod of the calibrator to different heights to generate different impact forces. The dynamic impact is connected to the sensor module of the oscilloscope. A number of force-measuring sensor modules with the same shape and thickness are manufactured, and 1 mm rubber buffer materials are used up and down.

Table 1: Output of force-measuring sensor module and conditioning circuit.

| Height | Force sensor module output/V | Conditioning circuit output/V |
|---|---|---|
| 0.01 | 9.5 | 2.3 |
| 0.02 | 19.7 | 3.2 |
| 0.03 | 32.5 | 5.6 |
| 0.04 | 66.2 | 11.0 |

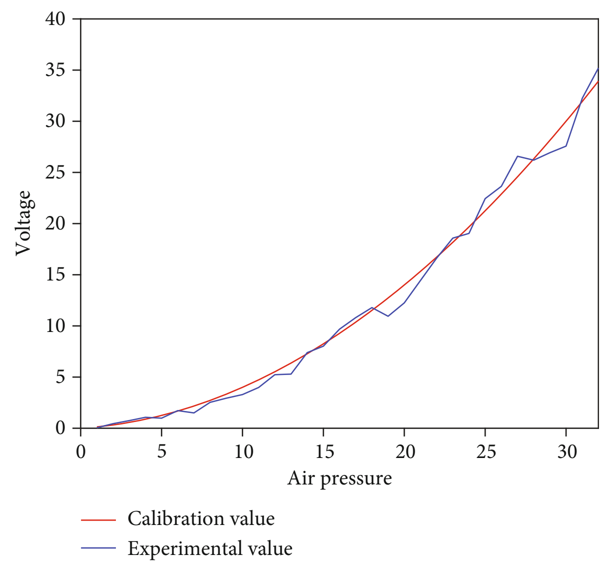


Figure 6: Pulse waves filtered by second-order Butterworth filter.

Connect the output signals vout+ and vout- of the air pressure sensor to P6.0 after differential amplification. The P6.0 port is set as its second function. The analog input channel 0 of the A/D converter performs A/D conversion. The reference voltage of the A/D converter selects the internal reference voltage as the reference. After the speed measurement program is completed, open the ADC, use the sampling timer, and convert the mode multiple times in a single channel. In the ad interrupt program, take the sampling value from ADC12MEM0, that is, the measured voltage. The relationship between voltage and punch force is obtained by experiment; place the fight trainer vertically with the target facing up. The measured output voltage values of weights with different weights are shown in Figure 6.

Figure 6 shows that the output voltage varies with the applied force; the output voltage of the sensor module of the same specification also exists because of the slight difference between the sensor itself and the buffer material -1.6 V~ +2 V difference. The relationship between the output voltage and force is similar to a linear function. Two load cell modules with the same shape and thickness and 1 mm plastic plate as buffer material are made for calibration. Change the thickness of the buffer material and the output voltage of the material, so as to distinguish the force-measuring sensors applicable to different levels and shapes of protective devices. Through programming, the collected voltage value

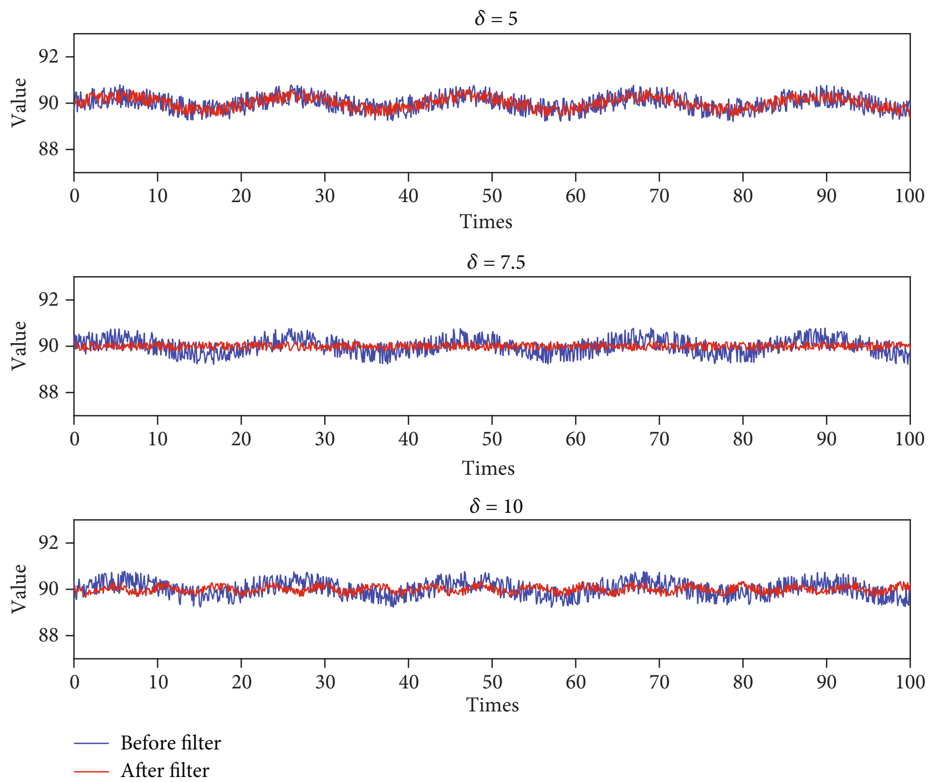


Figure 7: Analysis of filtering effect of low pass filter.

can be converted into the corresponding impact force during subsequent processing.

*4.2. Result Analysis of Wavelet Filtering Algorithm.* The selection of the window width parameter $\delta$ is the key. Theoretically, the larger the $\delta$ is, the better. In practical calculation, if $\delta$ is too large, it will bring a greater edge effect and increase the correlation of filtered data. Therefore, an appropriate compromise should be made between window width and edge effect (and data correlation), which is also a problem that must be considered by any filtering method. In this paper, the method of experimental debugging is used to take a value, that is, filter $\delta$ segment of analog data, and then adjust the size of $\delta$ so that the relative accuracy of filtering results can reach 0.5%.

The low-pass filter and second-order derivative filter are performed for $f(t)$, respectively. The scale parameters $\delta$ are taken take 5, 7.5, and 10, respectively. The filtering statistical results are shown in Figure 7.

It can be found that when $s$ is between 6 and 8 km, the 10 km term can be easily extracted with good accuracy. For $\delta = 10$, the filter has the best accuracy. However, considering that the relative accuracy has reached 0.5% when taking 7.5 and the large 8 value causes a large edge effect and data correlation, it can be considered that $\delta = 7.5$ is enough to meet the requirements. Since the filter must be of finite length, for the parent wavelet $\theta(t)$ and the parent wavelet $\psi(t)$. We only intercept $y \in [-20, 20]$, and more than 99.99% of the energy in the calculation table is concentrated in this interval.

The scale parameter $s$ is adjustable. The above filtering experiments only take four scales. In fact, after the basic parent wavelet and mother wavelet are constructed, people can filter on the desired scale by adjusting $s$. According to the data characteristics of the airborne gravimeter, it can be given that the scale range of $s$ is 1~100 km, which can meet the requirements of the airborne gravimeter for various resolutions.

*4.3. Validation of Combat Response Training Tester.* Aerobic boxing is a kind of aerobics that integrates boxing, taekwondo, and other fighting sports on the basis of traditional aerobics. With the accompaniment of music with a clear rhythm, the exercisers show their health, power, and pride between their cool fists and feet. Therefore, it is widely welcomed by college students, especially boys. This paper makes an experimental study on the introduction of aerobic fight gymnastics into college aerobic classes, aiming to improve the interest of college boys in taking part in fight sports, further improve the quality of fight teaching, and provide a basis for fight teaching. This paper makes an experimental study on the introduction of aerobics into aerobic classes in colleges and universities, aiming to improve the interest of college boys in participating in aerobics, further improve the quality of aerobic teaching, and provide a basis for aerobic teaching. The subjects were trained in aerobics once a week for up to 17 weeks, each time lasting for 90 minutes. The experimental group used an aerobic intervention method for teaching, and the control group used the three-

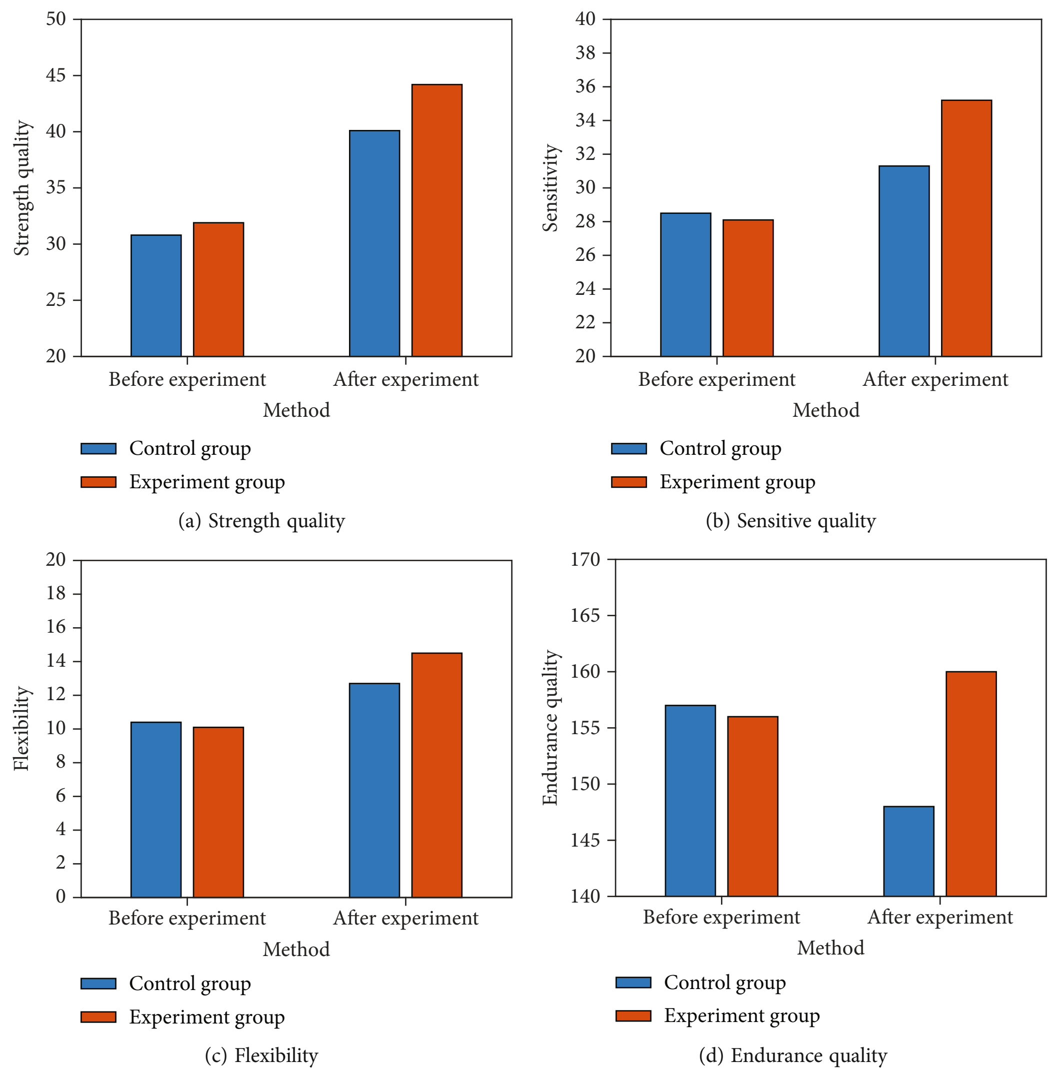


Figure 8: Comparison of physical test results between the control group and the experimental group.

level routine action of the "public aerobic grade exercise standard" [22]. During the experiment, the subjects generally did not participate in other forms of exercise. The experimental results are shown in Figure 8.

Before the experiment, there was no significant difference in physical fitness between the control group and the experimental group ($p > 0.05$); that is, the physical fitness level of the two groups of students was the same. After 17 weeks of aerobic intervention exercise, there were significant differences in four indicators of physical fitness between the two groups ($p < 0.05$), and the experimental group was significantly better than the control group in three indicators of strength, agility, and flexibility, and there was no significant difference in endurance quality between the two groups. It can be seen that aerobic exercise can significantly improve the physical quality of college boys, and the exercise effect is better than the standard routine exercise of mass aerobics. The experimental results show that the fighting instrument can effectively improve strength and sensitivity, and also improve flexibility and patience. Aerobic boxing can improve the interest of college boys in learning aerobics and improve the imbalance between men and women in the teaching of boxing. Aerobic boxing exercises can significantly improve the strength, flexibility, agility, and endurance of students. From the final special skill examination results of aerobics in the experimental group and the control group, boys have higher enthusiasm and initiative in learning aerobics and better learning effect.

## 5. Conclusion

Based on the basic principle and theory of embedded design, combined with the design practice of traditional fight training device, this paper analyzes and studies the design of other related fitness equipment, including hardware simulation and software simulation, and basically grasps the design theory and design principle of comprehensive fight training system. In the design process, the sp430 single-chip microcomputer is used to store and calculate the data collected by the ultrasonic sensor and the air pressure sensor. At the same time, a force-measuring sensor for combat competition based on the e-touch piezoelectric film is proposed. The voltage follower with convenient conversion, high sensitivity, and good output voltage ratio is used as its conditioning circuit for the subsequent AD conversion. The output voltage is corresponding to the impact force through calibration, so as to prepare for the accurate calculation of the force, duration, and frequency. In addition, this paper mainly uses the wavelet filtering algorithm to process the data collected by the data sensor and obtains relatively high accuracy. The experiment shows that the introduction of a combat-testing instrument based on an intelligent sensor can help to improve the interest of training, improve the training effect, and promote the popularity of combat sports in the world. The wireless communication technology is used to connect all the fight trainer systems with the upper computer, and a database system is established, which contains the personal test records of each user. As a result, all test equipment in the same gym can be connected with the upper computer to establish a comprehensive user database system.

## Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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